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FOREST SERVICE
In Cooperation with the University of Wisconsin

HARDBOARDS FROM MIXTURES OF COLOMBIAN AND GHANAIAN HARDWOODS

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Summary

This report establishes the suitability of Colombian and Ghanaian hardwood mixtures for the manufacture of hardboard. Low energy was required to fiberize the chips into hardboard fiber. High-density hardboards made from both chip mixtures by both the dry- and wet-formed processes met the Voluntary Product Standard for standard hardboard, with the exception of the dry-formed hardboards with 2 percent resin. Dry-formed, medium-density hardboard made with urea resin had strength properties suitable for furniture core stock. Medium-density hardboard made with phenol-resorcinol resin had strength and accelerated aging properties suitable for exterior siding application. All hardboards had excellent surface characteristics, which are desirable in finishing.

Experimental

Wood Mixtures

Seventeen species of Colombian hardwoods (table 1) and 22 species of Ghanaian hardwoods (table 2) were used to make the pulps for the hardboard

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1/ Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

trials. The chips were made from bark-free wood in a commercial-size, four-knife chipper. The nominal length of the chips was five-eighths inch, and the fines and oversize materials were removed prior to blending of individual species to obtain the chip mixtures described in tables 1 and 2. The weighted average specific gravity of the Colombian mixture was 0.667, and that of the Ghanaian mixture was 0.470.

Pulp Preparation

Chips were converted into hardboard quality pulp using a Bauer 418 pressurized refiner in the pilot plant of C. E. Bauer, Springfield, Ohio. Chips from both mixtures were refined at 85 pounds per square inch and 3.5-minute retention time. The amount of energy used in producing these pulps was 6.1 horsepower-days per air-dry ton for the Colombian mixture and 5.7 horsepower-days per air-dry ton for the Ghanaian mixture.

Boardmaking

Dry-formed, 1/8-inch, high-density hardboards were made at the Forest Products Laboratory. The pulps were first air dried and then sprayed with either 2 or 4 percent resin by weight, based on the pulp, while tumbling in a rotating drum. The resin was a phenol-formaldehyde type commonly used for dry-formed hardboard. Fourteen- by fourteen-inch mats were formed on a banjo-type former, cold pressed, and then hot pressed between platens at a temperature of 375° F. for 6 minutes.

Wet-formed, 1/8-inch, high-density hardboards were also made at the Forest Products Laboratory. The pulp in a water slurry was treated with 1 percent phenol-formaldehyde resin of a type commonly used for wet-formed

hardboards and 0.75 percent wax size. Eight-inch-diameter mats were formed in the Asplund Drainage Tester, cold pressed, and then hot pressed at a platen temperature of 375° F. for 6 minutes.

Dry-formed, medium-density hardboards, approximately 32 by 34 inches, were made in the pilot plant of Miller-Hofft, Richmond, Va. The fiber, after flash drying, was treated with 1 percent wax size and 8 percent urea-melamine resin or phenol-resorcinol resin. The mats were pressed in a high-frequency press and the boards shipped to the Forest Products Laboratory.

All of the high-density hardboards and the medium-density hardboards made with phenol-resorcinol resin were given a further heat treatment by exposing them for 1 hour in a circulating-air oven at 320° F.

Test Methods

Evaluations were made on test specimens preconditioned 30 days at 50 percent relative humidity and 73° F. using test procedures specified in ASTM Standard D 1037-72a (1)[2/] with the following exception. Dimensional movement was determined on 1/2- by 6-inch specimens preconditioned for 30 days at 50 percent relative humidity, followed by exposure to the following conditions: (1) 90 percent relative humidity and 80° F. for 30 days, (2) immersion in water for 30 days, and (3) drying in an oven at 220° F. for 72 hours. Length, thickness, and weight changes were determined before and after exposure to each condition.

2/ Underlined numbers in parentheses refer to literature cited at the end of this report.

Results

Pulp Preparation

The amount of power used to prepare pulps from the Colombian and Ghanaian mixtures was comparable to that required to pulp domestic hardwoods, but greater than the power required for the Philippine hardwood mixtures. The Philippine mixtures were processed using a plate gap of 0.051 inch, whereas plate gaps of 0.020 and 0.007 inch were used for the Colombian and Ghanaian mixtures, respectively, to obtain a satisfactory fiber for dry forming.

High-Density Hardboard

Dry formed.--With one exception, dry-formed hardboards made from the Colombian and Ghanaian mixtures met the requirements of Voluntary Product Standard PS 58-73 (2) for those properties evaluated. The exception was for hardboards made from the Colombian mixture using 2 percent phenolic resin, where all the strength properties were below the standard. However, these boards did have excellent linear stability.

With the Ghanaian mixture and 2 percent phenolic resin, the dry-formed hardboards just met the minimum requirements for modulus of rupture and tensile strength, with the internal bond strength well above the minimum. The linear stability likewise was good.

With both the Colombian and Ghanaian mixtures, increasing the phenolic resin content to 4 percent yielded strength properties which were much higher than required. Linear movement between 50 and 90 percent relative humidity was minimal. Based on the results, it would appear that about

3 percent resin would be adequate in producing acceptable dry-formed high-density hardboard from these hardwoods.

Wet formed.--Good-quality wet-formed boards were made with 1 percent resin addition. Boards made from the Colombian and Ghanaian mixtures greatly exceeded the requirements of the Product Standard for those properties evaluated. Linear movement was very good for both sets of boards. Obviously, something less than 1 percent resin would be required with these mixtures in producing satisfactory wet-formed hardboards.

Medium-Density Hardboards

Medium-density hardboards of good quality were made from Colombian and Ghanaian mixtures (table 4). The 3/4-inch-thick boards bonded with urea-melamine resin had good surface and edge characteristics and good linear stability--desirable properties for use in furniture. While they did not possess as high strength and stiffness as commercial boards (3) now used by the furniture industry in the United States, these properties are of secondary importance for many furniture applications. If more strength is needed, this can undoubtedly be achieved with an increase in board density or with the addition of more resin binder. These experimental boards had much better linear stability than the commercial boards. A portion, but not all, of the linear movement differences could be attributed to the different humidity exposures. Thickness swelling was also very low for both chip mixtures. Excellent linear and thickness stabilities are very important properties for use in furniture.

The 7/16-inch, 48-pound-per-cubic-foot density boards were investigated as a potential product for siding, since a durable adhesive was used. With one exception, all the boards retained 50 percent or more of their initial strength both after water soaking and after accelerated aging. Internal bond strength was the exception, with only a 25 percent strength retention after accelerated aging. As a group, boards made from the Ghanaian chip mixture were slightly stronger than boards made from the Colombian chip mixture. However, boards from both chip mixtures were nearly equal, with very little dimensional movement. Boards made from both chip mixtures should be suitable for siding because of their good strength retention after water soaking and accelerated aging and good dimensional movement.

Conclusions

(1) The Colombian and Ghanaian hardwood mixtures can be easily converted into good-quality, pressurized refined pulp, consuming less energy than required for most U.S. species.

(2) Colombian or Ghanaian hardwood mixtures can be used with minimal effect on hardboard quality.

(3) Good-quality, high-density hardboards can be made by either the dry- or wet-forming process.

(4) Medium-density hardboards from the Colombian and Ghanaian hardwood mixtures, when bonded with a conventional urea resin system, are suitable for furniture use and, when bonded with phenol-resorcinol, are sufficiently durable for exterior use.

Literature Cited

(1) American Society for Testing and Materials.

1972. Standard methods of evaluating the properties of wood-base fiber and particle panel materials. Annual Book of ASTM Standards, Pt. 16, ASTM D 1037-72A.

(2) National Bureau of Standards.

1973. Basic hardboard. Voluntary Product Standard PS 58-73, U.S. Dep. Commerce.

(3) Superfesky, M. J., and W. C. Lewis.

1974. Basic properties of three medium-density hardboards. U.S. Dep. Agric. For. Serv. Res. Paper FPL 238.

Table 1.--Names, specific gravities, and composition of the Colombian hardwood mixture B used to make hardboards

Species		Specific gravity[1]	Mixture composition[2]
Common name	Botanical name		
			Pct
Ceiba	Ceiba pentandre	0.225	1
Yarumo	Cecropia sp.	.250	1
Cirpo	Pourouma sp.	.369	2
Chingale	Jacaranda copaia	.372	2
Dormilon	Vochysia ferruginea	.447	3
Sande	Brosimum utile	.494	3
Sangretoro	Virola sebifera	.511	3
Arenillo	Catostemma alstonii	.536	5
Canelo	Nectandra sp.	.546	5
Perillo negro	Couma macrocarpa	.547	5
Casaco	Hieronyma sp.	.603	6.7
Carbonero	Enterolobium schomburgkii	.634	6.7
Chocho	Ormosia paraensis	.671	6.7
Carreto	Aspidosperma sp.	.692	12.5
Lecheperra	Helicostylis tomentosa	.785	12.5
Tamarindo	Dialium guianense	.823	12.5
Caimo	Pouteria sp.	.859	12.5

1/ Dry weight, green volume basis.
2/ Moisture-free wood basis.

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Table 2.--Names, specific gravities, and composition of the Ghanaian hardwood mixture A used to make hardboards

Species: Common name	Species: Botanical name	Specific gravity[1]	Mixture composition[2]
			Pct
Otu	Cleistopholis patens	0.241	4.55
Effeu	Hannoa kleineana	.283	4.55
African corkwood	Musanga cecropioides	.301	4.55
Obeche	Triplochiton scleroxylon	.302	4.55
Antiaris	Antiaris africana	.312	4.55
Canarium	Canarium schweinfurthii	.337	4.55
Akoret	Discoglypremna caloneura	.370	4.55
African mahogany	Khaya ivorensis	.413	4.55
Dahoma	Piptadeniastrum africanum	.442	4.55
Gedu nohor	Entandrophragma angolense	.450	4.55
Niangon	Tarrietia utilis	.460	4.55
Scented guarea	Guarea cedrata	.485	4.55
Makore	Tieghemella heckelii	.499	4.55
Tallow tree	Allanblackia floribunda	.540	4.55
Lokonfi	Celtis adolphi-friderici	.549	4.55
Brown sterculia	Sterculia rhinopetala	.552	4.55
Eyong	Sterculia oblonga	.589	4.55
Adjouba	Dacryodes klaineana	.692	4.55
Afina	Strombosia glaucescens	.697	4.55
Kane	Anogeissus leiocarpus	.708	4.55
Kokoti	Anopyxis kleineana	.721	4.55
Ekki	Lophira alata	.808	4.55

1/ Dry weight, green volume basis.
2/ Moisture-free wood basis.

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Table 3.--Properties of 1/8-inch-thick, high-density hardboards

Source of chip mixture	Resin content	Static bending[1/]		Internal bond strength	Tensile strength	Dimensional movement			
		Modulus of rupture	Modulus of elasticity			From 50-90 pct relative humidity		From 50 pct relative humidity to water soak	
						Length	Thickness	Length	Thickness
	Pct	Lb/in^2	$1,000\ lb/in^2$	Lb/in^2	Lb/in^2	Pct	Pct	Pct	Pct
DRY FORMED									
Colombia	2	3,080	340	97	1,810	0.13	12.2	0.08	32.6
Do......	4	7,020	610	198	3,850	.07	6.9	.07	18.4
Ghana	2	5,100	590	192	2,660	.11	10.9	.12	31.6
Do......	4	8,080	720	303	4,320	.08	6.9	.09	17.6
WET FORMED									
Colombia	1	8,110	590	431	--	.08	8.8	.28	34.7
Ghana	1	8,380	600	354	--	.13	9.3	.36	36.7

1/ All values adjusted to 60-lb/ft^3 density.

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Table 4.--Properties of dry-formed, medium-density hardboards

Source of chip mixture	Resin type[1/]	Condition at test	Static bending[2/]: Modulus of rupture	Static bending[2/]: Modulus of elasticity	Internal bond strength	Tensile strength	Dimensional movement: From 50-90 pct relative humidity: Length	Dimensional movement: From 50-90 pct relative humidity: Thickness	Dimensional movement: From 50 pct relative humidity to water soak: Length	Dimensional movement: From 50 pct relative humidity to water soak: Thickness
	Pct		Lb/in^2	$\frac{1,000}{lb/in^2}$	Lb/in^2	Lb/in^2	Pct	Pct	Pct	Pct
3/4 IN. THICK, 42-LB/FT^3 DENSITY										
Colombia	Urea--6 pct melamine	Dry	3,340	380	142	2,560	0.15	6.7	0.21	30.8
Do...	.........do.........	Wet	2,140	200	--	--	--	--	--	--
Ghana	.........do.........	Dry	3,870	420	134	2,770	.15	6.7	.21	27.9
Do...	.........do.........	Wet	2,230	200	--	--	--	--	--	--
7/16 IN. THICK, 48-LB/FT^3 DENSITY										
Colombia	Phenol-resorcinol	Dry	3,570	420	164	2,640	.11	7.4	.14	14.9
Do...	.........do.........	Wet	2,550	250	--	2,270	--	--	--	--
Do...	.........do.........	Aged	2,080	210	41	1,610	--	--	--	--
Ghana	.........do.........	Dry	4,530	490	236	3,250	.11	6.1	.16	12.9
Do...	.........do.........	Wet	3,100	280	--	2,650	--	--	--	--
Do...	.........do.........	Aged	2,860	270	60	2,180	--	--	--	--
AVERAGE OF 3 U.S. COMMERCIAL MEDIUM-DENSITY HARDBOARDS, 3/4 IN. THICK, 44-LB/FT^3 DENSITY										
United States	Urea--6 pct melamine	Dry	4,880	510	153	2,770	[3/] .47	--	--	--

1/ Total resin content was 8 pct.

2/ All values adjusted to either 42- or 48-lb/ft^3 density (except for aged specimens).

3/ Linear expansion from 30 to 90 pct relative humidity.

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